Mactaquac Aquatic Ecosystem Study (MAES)

Mactaquac Hydro-Electric Generation Station Renewal Project

MACTAQUAC AQUATIC MAES ECOSYSTEM STUDY

NSERC CRSNG

Énergie NB Power

Canadian Rivers Institute

INRS UNIVERSITÉ DE RECHERCHE

UNB

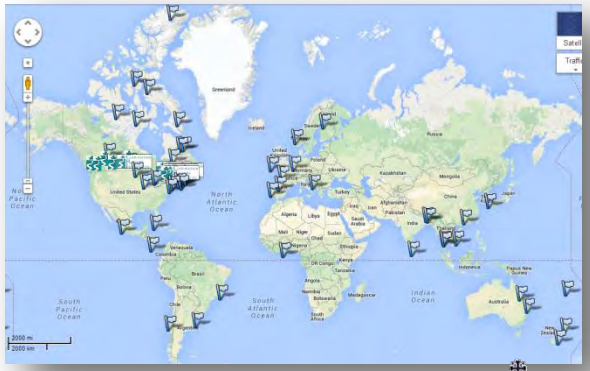
Canadian Rivers Institute

VISION: to make every river a healthy river

- Created at the University of New Brunswick in 2001
- Centre of excellence in water sciences, management, and education
- Aquatic science needed to understand, protect and sustain water resources in Canada and abroad
- An international, open network of research collaboration hosted at UNB
- 19 Science Directors-3 countries

CRI's Research Priorities

- Innovative science to create a paradigm shift in river management
- Develop meaningful indicators and thresholds of change for river ecosystems
- Linking flow and biological processes in rivers
- Advancing monitoring & management practices



Wilfrid Laurier University · University of Waterloo · UNB · University of Prince Edward Island · Universidad de Guadalajara · SNC·Lavalin · PROTHEA · INRS · Environment Canada / Environnement Canada · New Brunswick Nouveau-Brunswick Canada · Fisheries and Oceans Canada / Pêches et Océans Canada

Project Summary

MACTAQUAC AQUATIC MAES ECOSYSTEM STUDY

- MAES is a **multi-year, whole-river ecosystem study**
  - Phase 1 - Modelling of the structure and function of a large river ecosystem → the first four years of study (ongoing 4 years – NB Power / NSERC CRD grant)
  - Phase 2 – "Construction" - Manipulating flow, sediment transport, and the thermal regime (10 years)
  - Phase 3 - Monitoring the river's recovery to a new state (10 years)
- **Phase 1 - Three key components**:

  (1) whole ecosystem; (2) fish passage; and (3) environmental flows
- **Key outputs**:
  - Deliverables to NB Power to support the Mactaquac Project – planning of the project
  - Training of 49 HQP (Undergraduate, M.Sc., M.Eng., Ph.D. and PDF)
  - Dissemination of results to public and scientific community

MAES Management Team / Science Advisory Board

- Allen Curry
  Principal Investigator
- Gordon Yamazaki
  Project Manager
- Tommi Linnansaari
  Research Associate – Co-Lead
- Wendy Monk
  Research Associate – Co-Lead




<u>Science Advisory Board</u>

- *Stuart Bunn, ARI/Griffiths*
- *Jeff Duda, USGS*
- *Loren Grieg, ESSA*

MAES Project Team

- Dr. Donald Baird (Environment Canada and CRI)
- Dr. Karl Butler (UNB)
- Dr. Joseph Culp (Environment Canada and CRI)
- Dr. Katy Haralampides (UNB)
- Dr. John Hughes Clarke (UNB)
- Dr. Karen Kidd (UNB and CRI)
- Dr. Stephan Peake (UNB)
- Dr. André St-Hilaire (INRS and CRI)

UNB

INRS
Université d'avant-garde

Canadian Rivers Institute

Environment Canada
Environnement Canada

MAES Collaborators

- NB Power
- Fisheries and Oceans Canada
- New Brunswick Department of Natural Resources
- New Brunswick Department of Environment
- Acadian Sturgeon and Caviar, Inc.
- Universität Stuttgart (Schneider & Jorde Ecohydraulic Engineering)
- Canadian Hydrographic Service
- Biodiversity Institute of Ontario (Dr. Mehrdad Hajibabaei)
- Mount Allison University (Dr. Felix Bärlocher)

Énergie NB Power

Canadian Hydrographic Service / Service hydrographique du Canada

Universitas Montis Allisoniani Sackvillae MDCCCXXXIX

Acadian Sturgeon and Caviar Inc.

New Nouveau Brunswick
Be...in this place • Être...ici on le peut

Fisheries and Oceans Canada / Pêches et Océans Canada

BIO Biodiversity Institute of Ontario

sje Ecohydraulic Engineering, GmbH

Universität Stuttgart

MAES Project outline

- 1. Whole Ecosystem
  - 1A.1 Defining the river environment (**3 projects**)
  - 1A.2 River biomonitoring – baselines and metric development (**8 projects**)
  - 1B.1 Defining the reservoir environment (**6 projects**)
  - 1B.2 Downstream water release (**2 projects**)

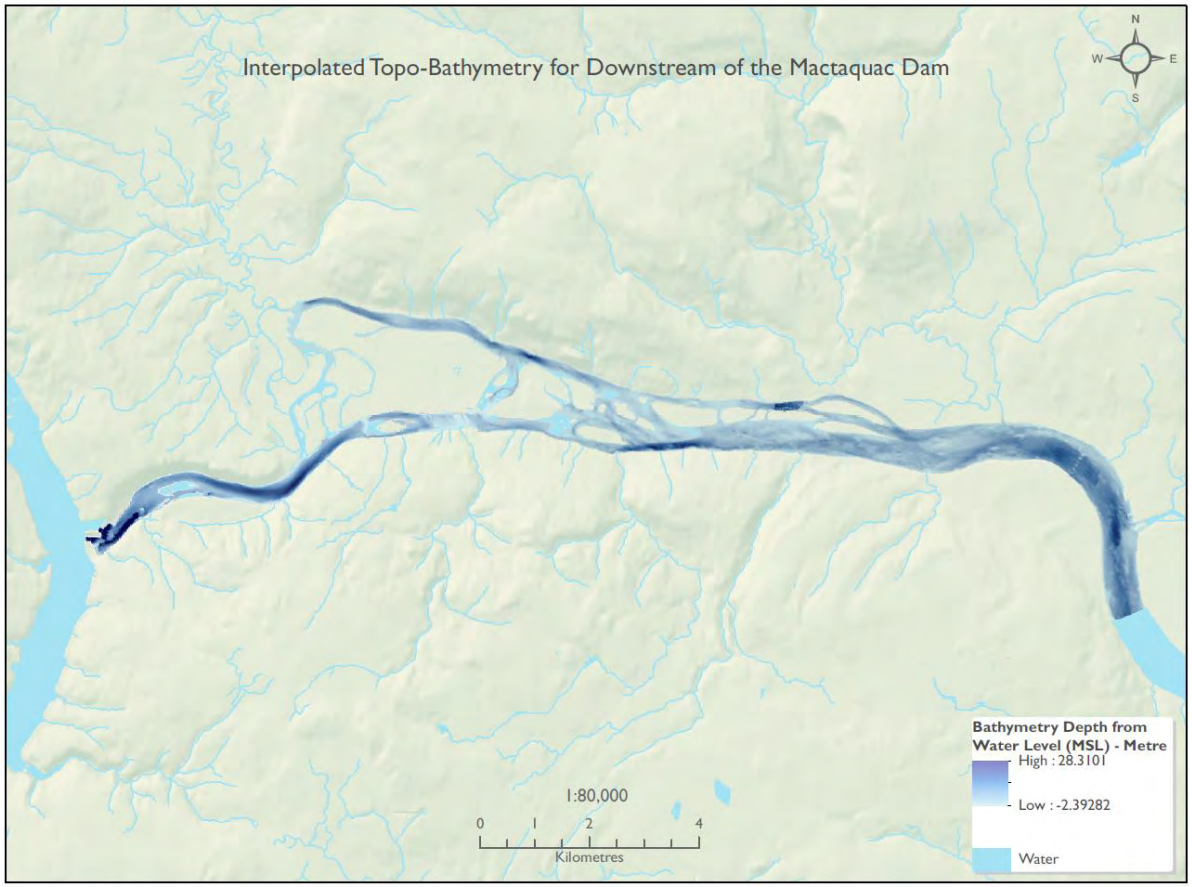
- 2. Fish Passage
  - 2.1 - 2.6 Atlantic salmon, striped bass, sturgeons, American eel, muskellunge (**6 projects**)

- 3. Environmental Flows
  - 3.1 - 3.4 Climate and future hydrological regimes, riparian zone insects, floodplain connectivity (**4 projects**)

Whole Ecosystem

Physical Baselines - River Bathymetry

- establish downstream bathymetry (MGS to Fredericton)
- 3D flow velocity (ADCP)
- interpolation of depth, sediment, and macrophytes density -“Biobase”
- LiDAR low flow

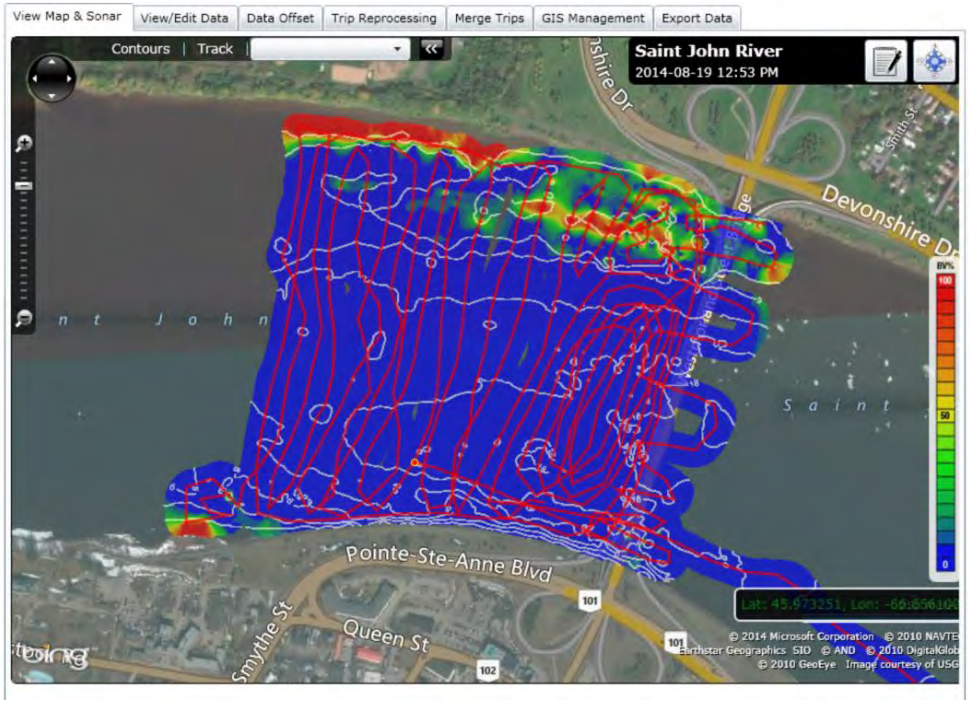


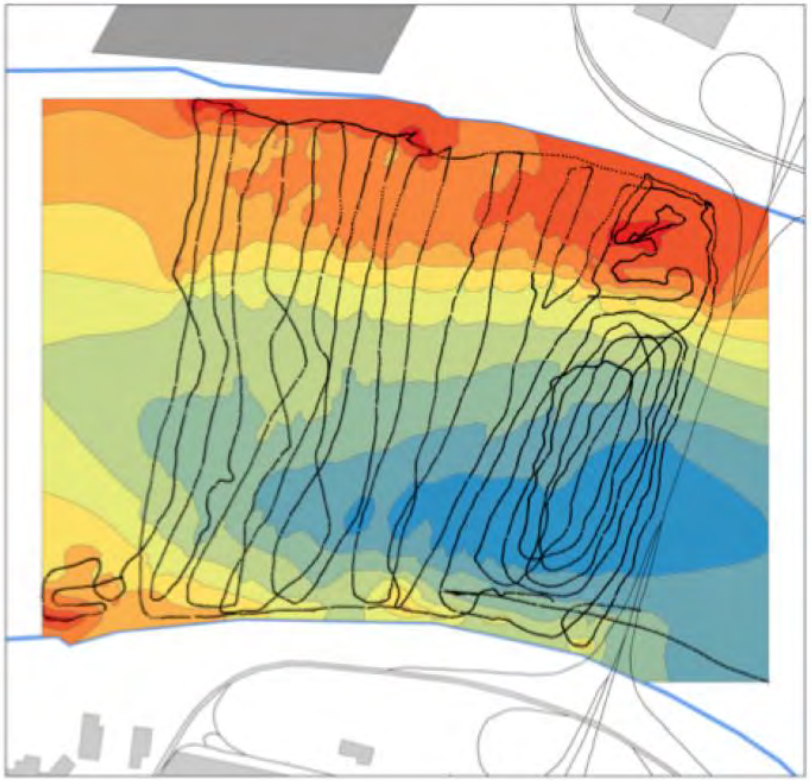
Leading Edge Geomatics

BIOBASE

Mapping surveys

- Downstream mapping – Bathymetry, Macrophytes, Sediments

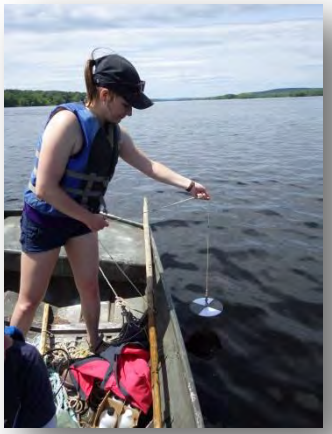


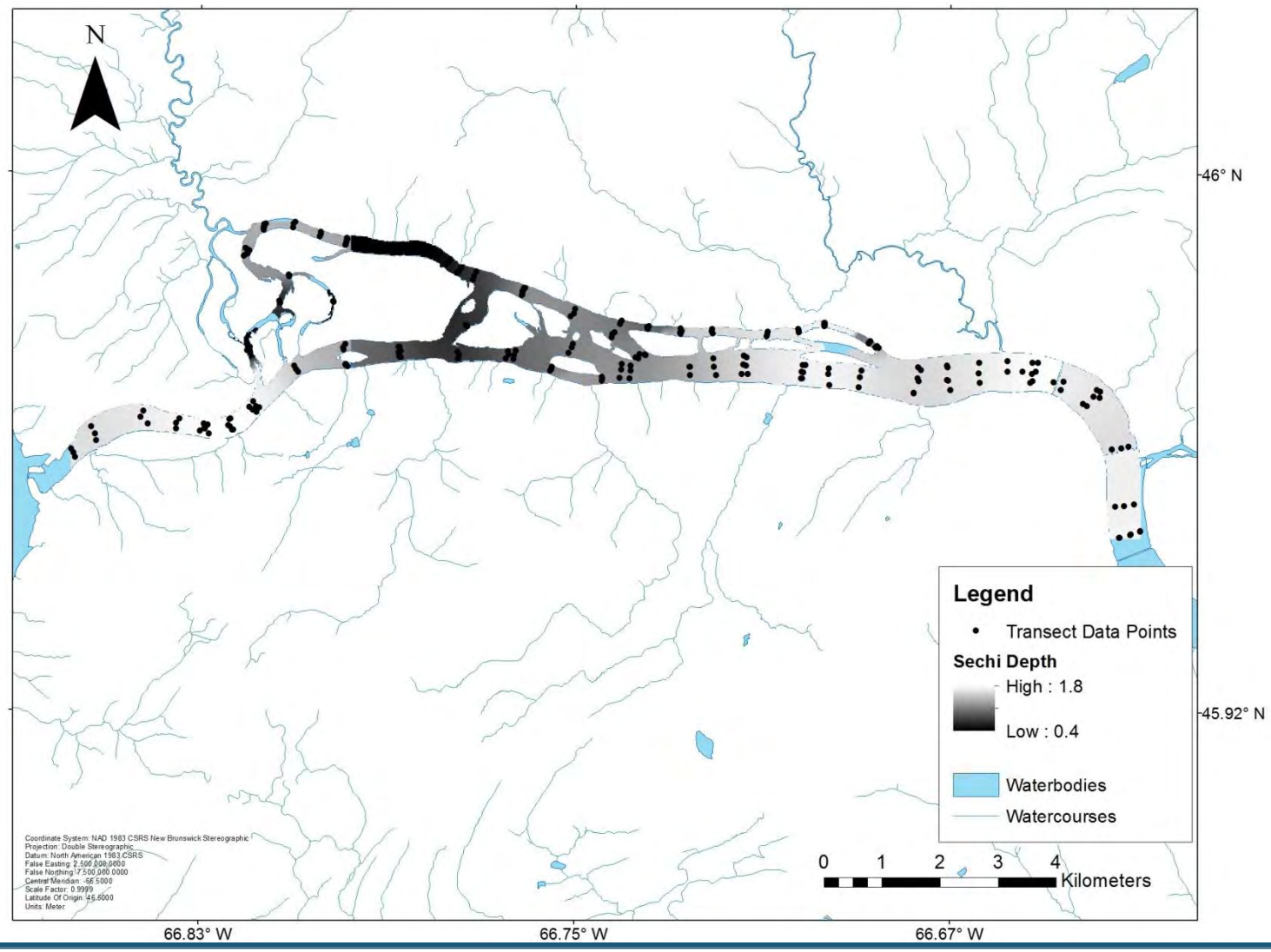


Physical Baseline

Downstream - Mapping of habitat characteristics

- Secchi depth



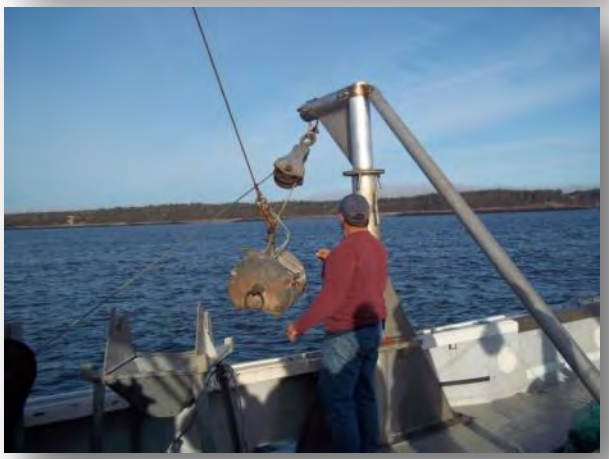


Reservoir Mapping

MVP drop locations - June 25th 2014

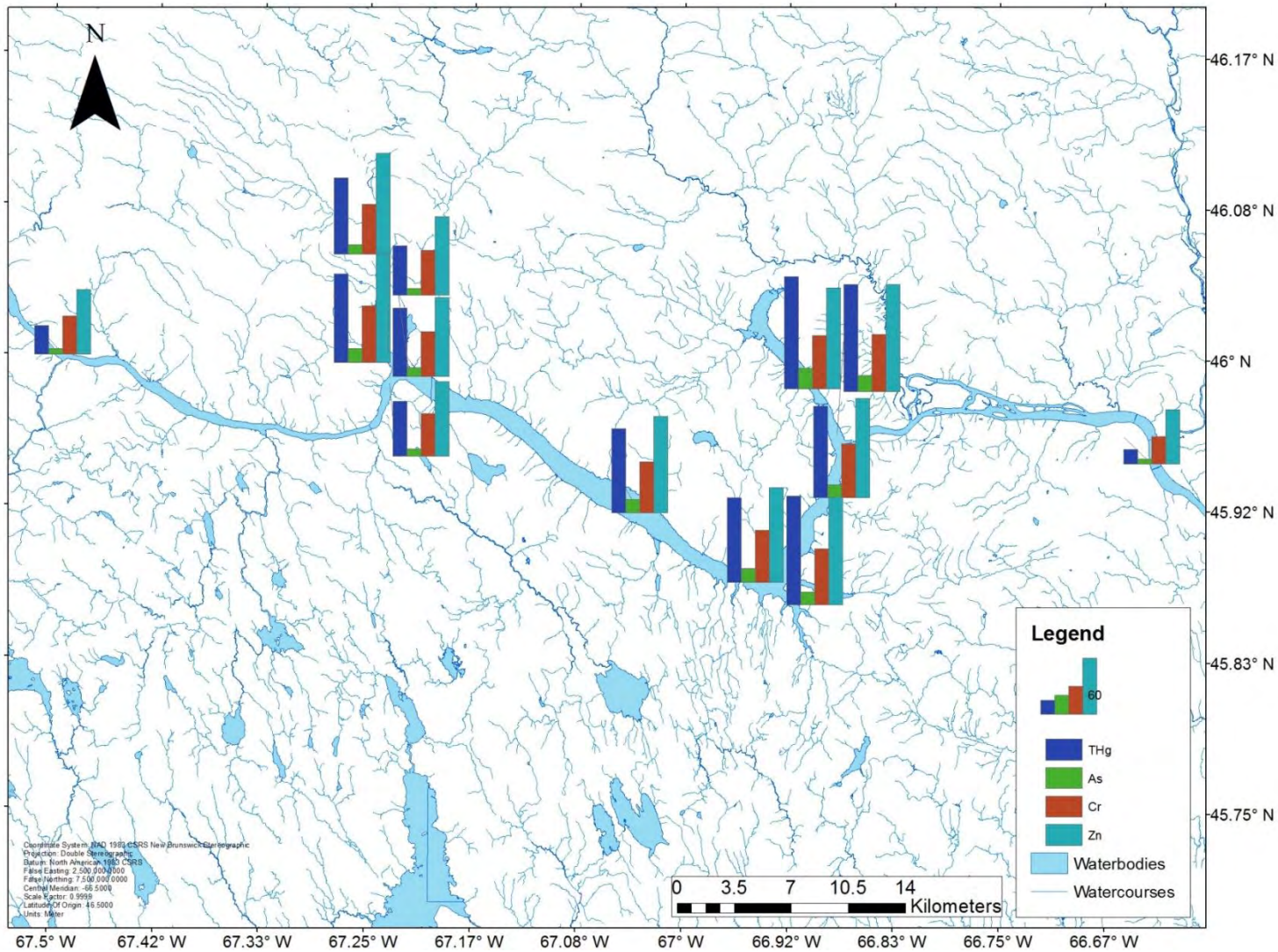
1B.1.3 Reservoir sediment composition, chemistry, and potential for downstream displacement

- Baseline data on sediment composition and contaminants are needed to model downstream effects
  - Sample sites in headpond selected based on bathymetry and sediment layering studies
  - Sample sites downstream of MGS
- Examine spatial variability and magnitude of contaminant and nutrient concentrations

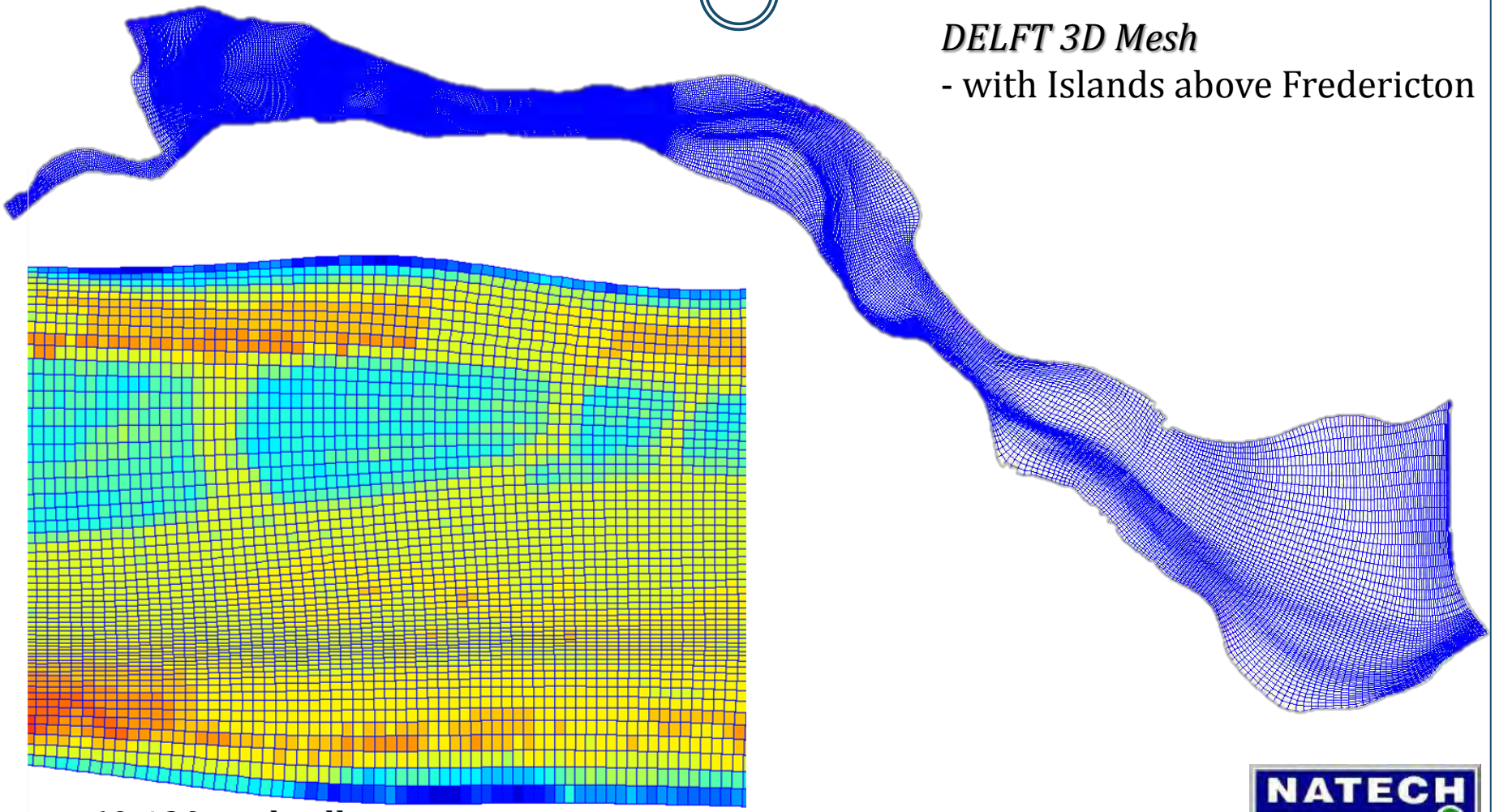


Source: K. Kidd

Sediment Metals



DELFT 3D Models



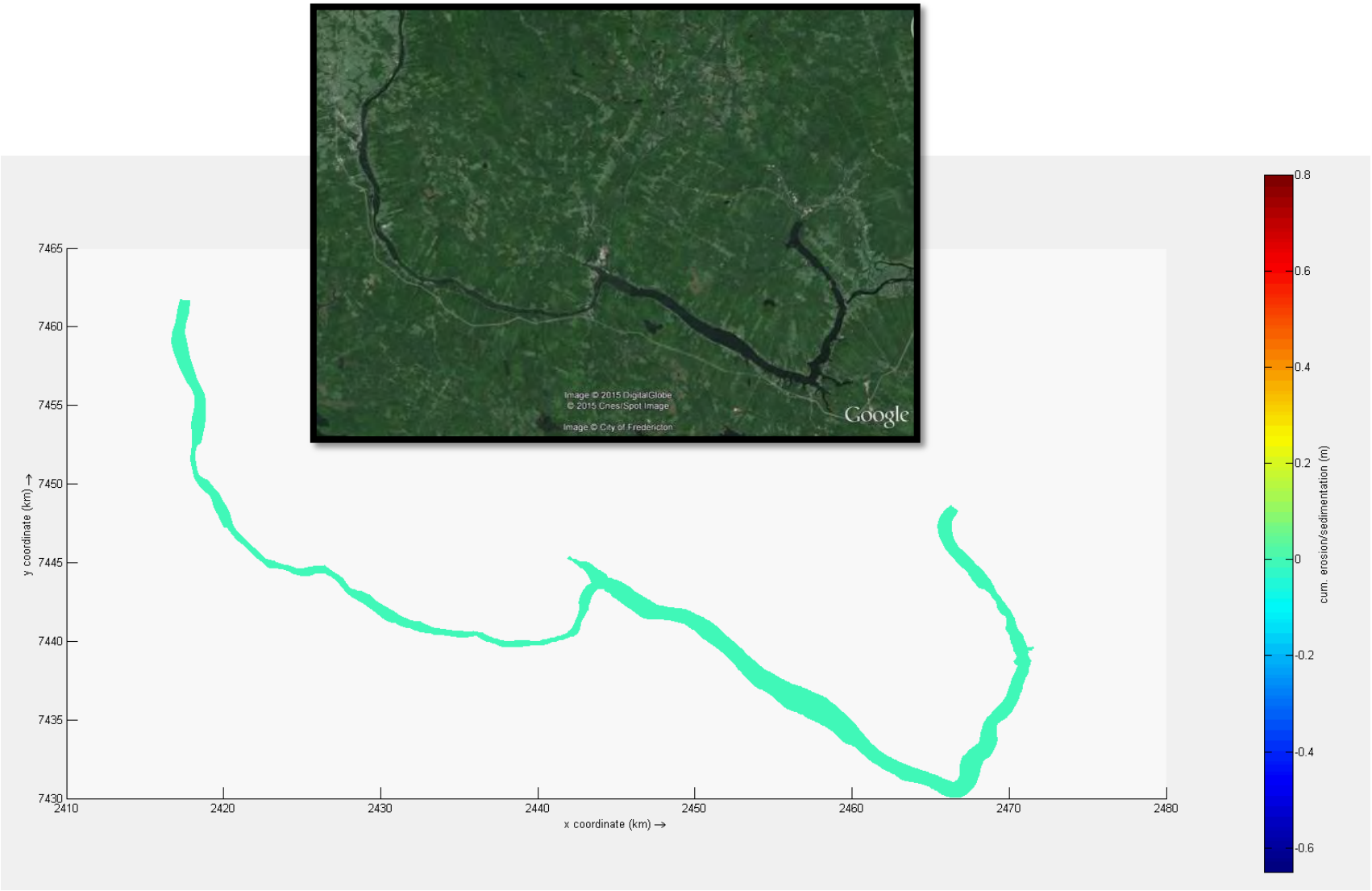
DELFT 3D Mesh

- with Islands above Fredericton

60,420 grid cells

NATECH

MACTAQUAC AQUATIC MAES ECOSYSTEM STUDY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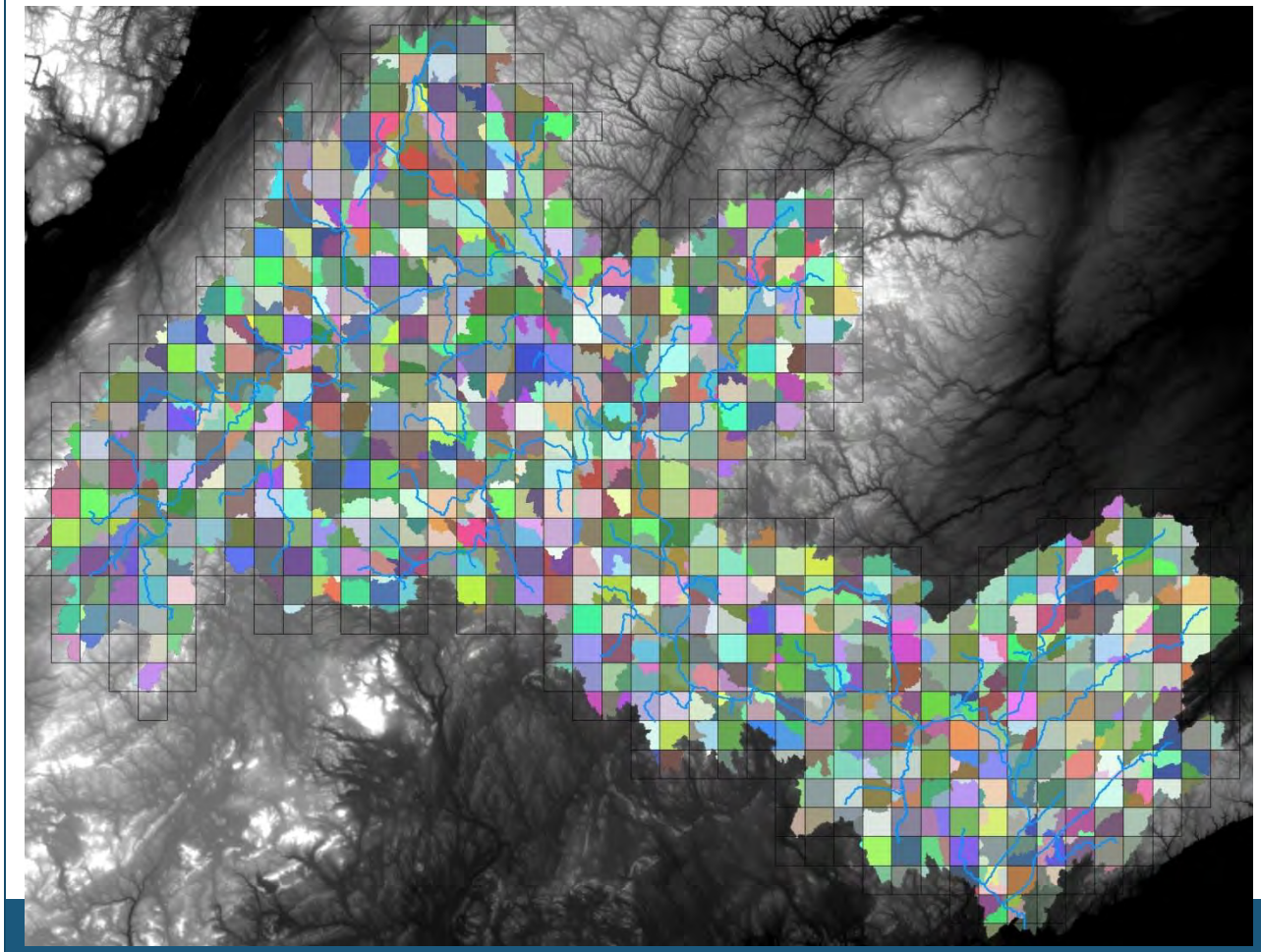
Google
7465
7460
7455
7450
7445
7440
7435
7430
y coordinate (km) →
2410
2420
2430
2440
2450
2460
2470
2480
x coordinate (km) →
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
cum. erosion/sedimentation (m)

1B.2.2 Modelling predicted thermal regimes downstream during reservoir drawdown

- Accomplished using ArcGIS / Arc Hydro Tools

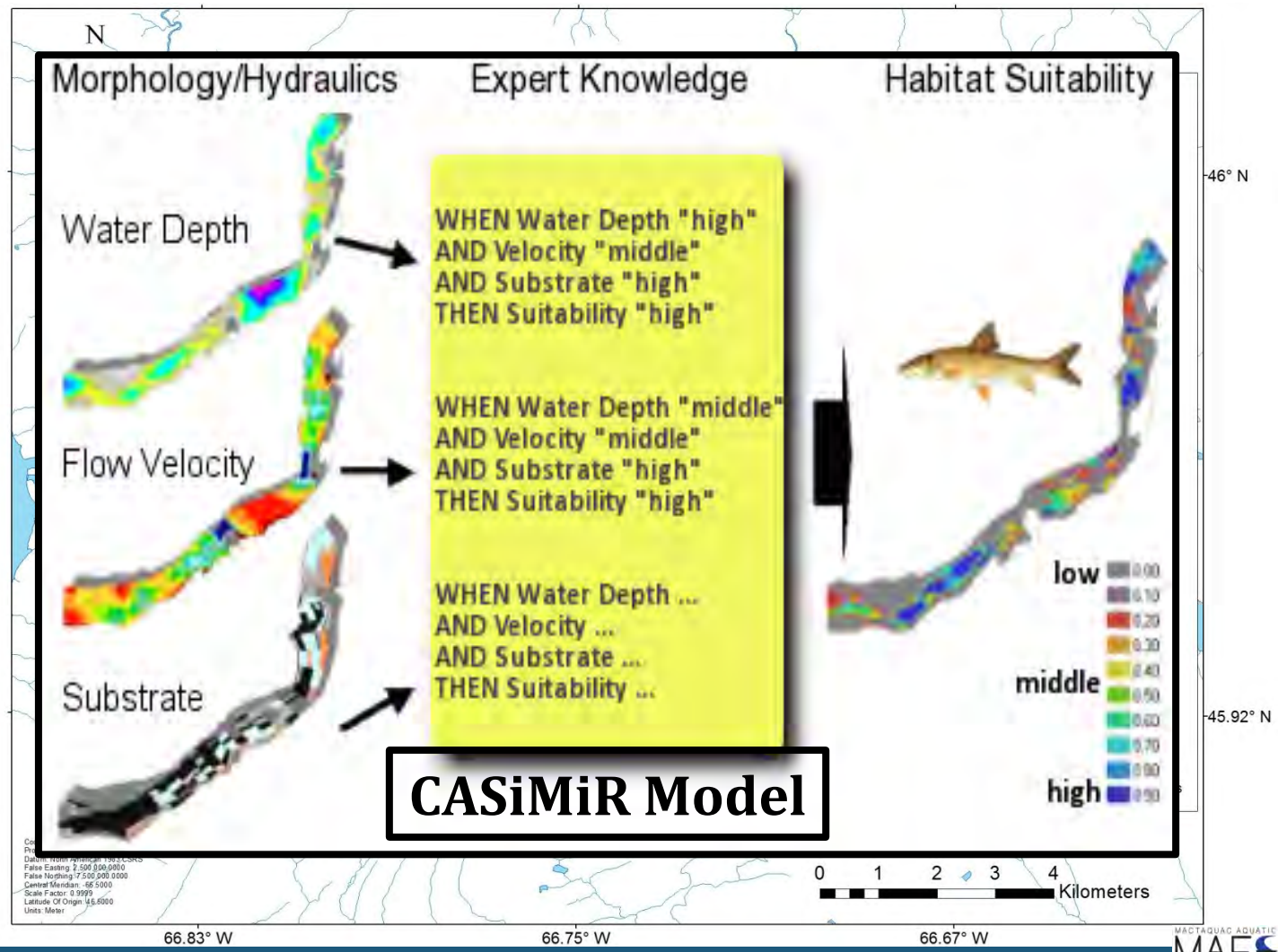


- Watershed divided into sub-basins of ~200 km^2 based on watershed divides
- CEQUEAU grid formed by further sub-dividing this into whole squares of 100 km^2

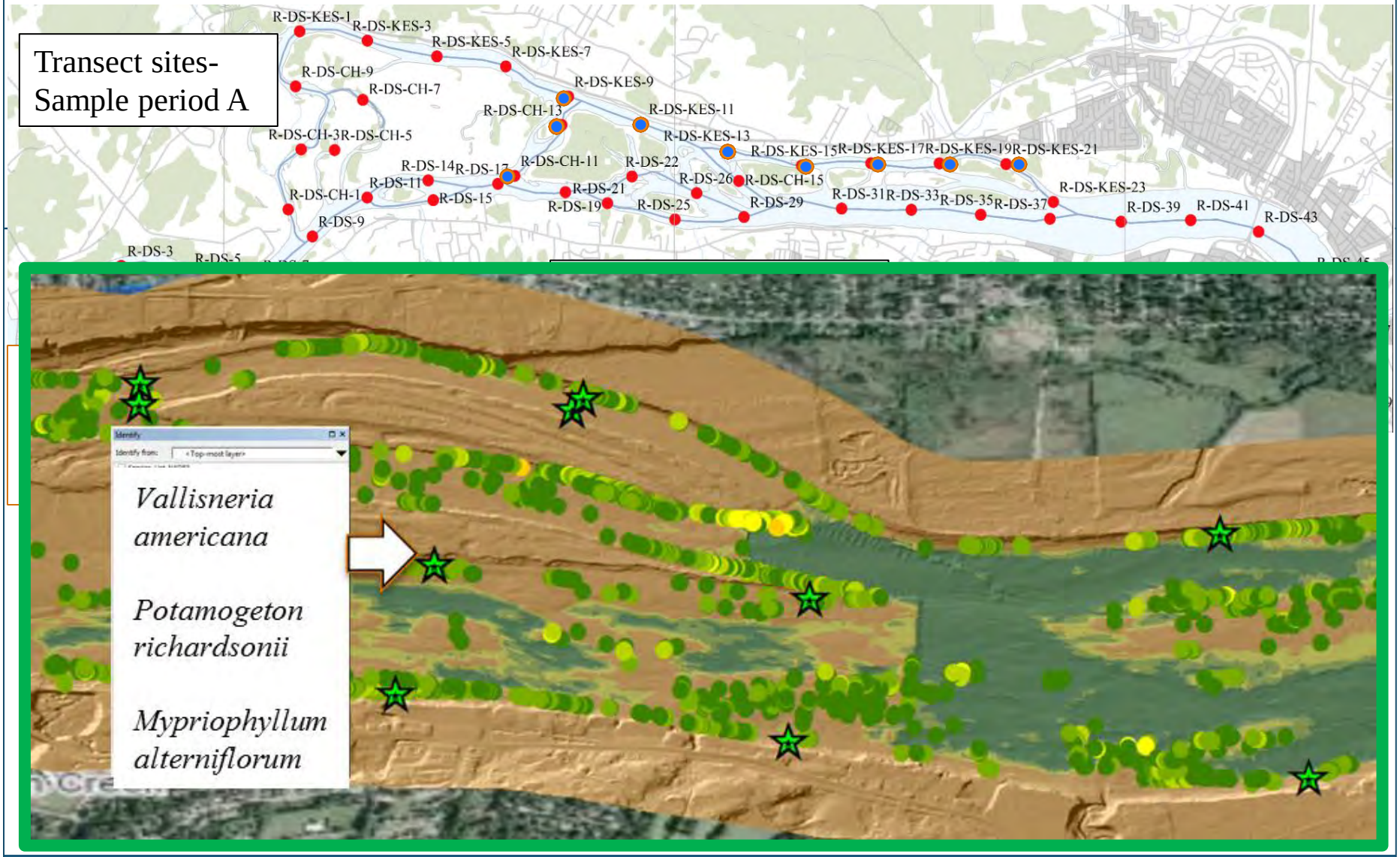
1A.2.1 River biotic structure

4.1 Metrics and Monitoring, 4.1.1 Fish Community
CRD 1A.2 River Biomonitoring - Baselines & Metric Development

- Fish community



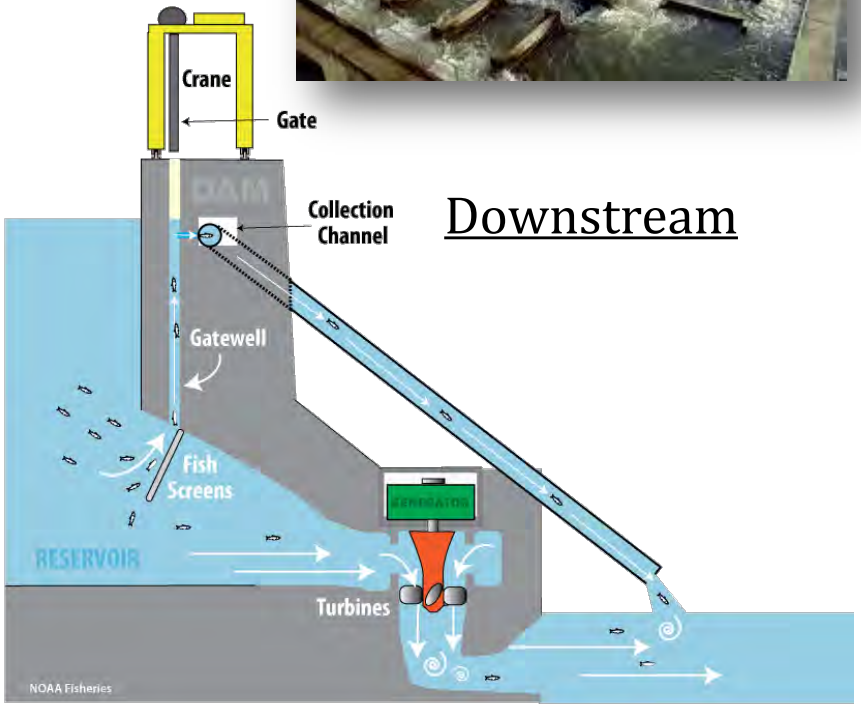
1A.2.3 Structure and Function: Macrophytes



2.0 Fish Passage / Habitats Studies

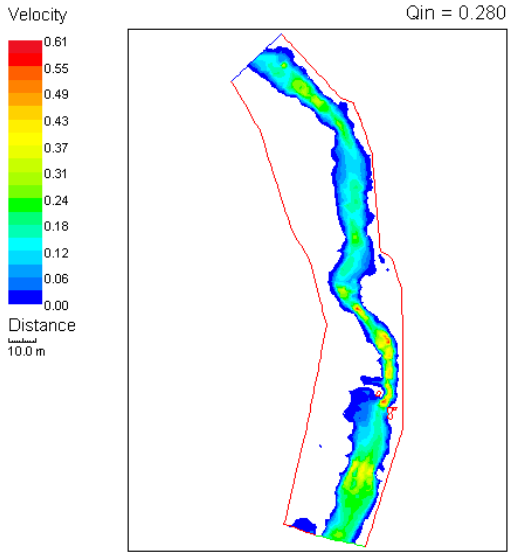
Passage

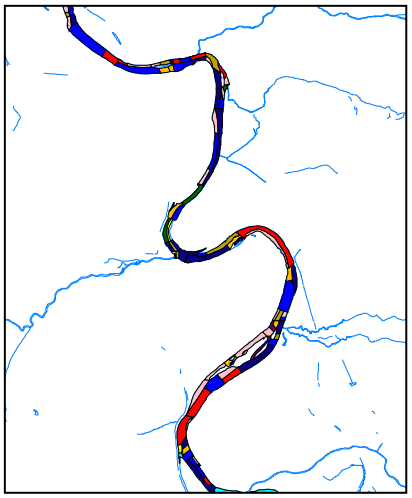
Upstream



Downstream

Habitats

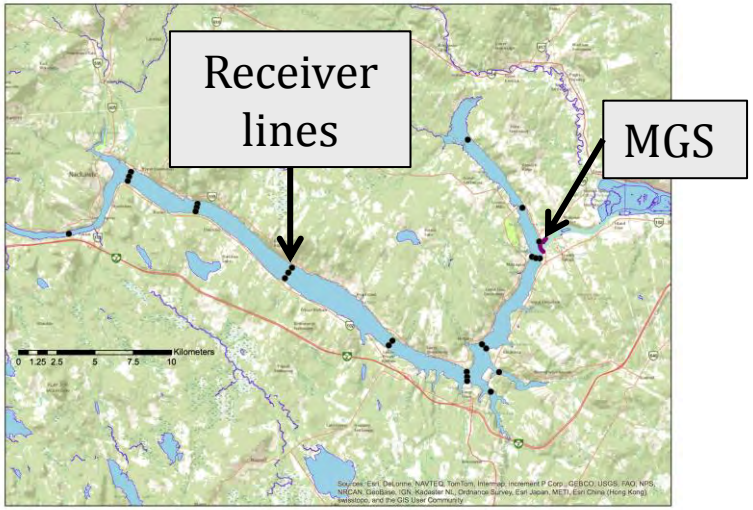




- Unknown
- Run (A)
- Deep Glide (B1)
- Shallow Glide (B2)
- Pool (C)
- Walk (D)
- Rapid (E)
- Cascade (F)
- Deep Splash (G1)
- Shallow Splash (G2)
- Rill (H)

2.1 Reservoir transit and downstream approaches to a large dam by Atlantic salmon

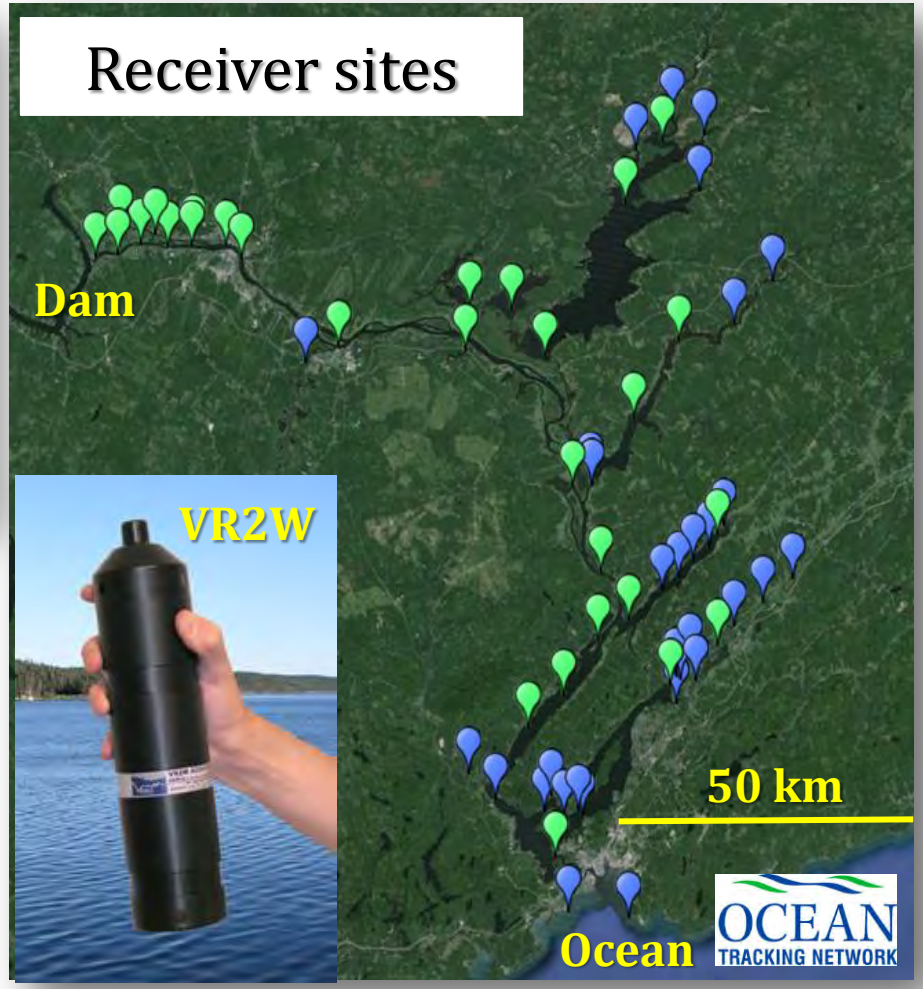
- Navigation of headpond, and MGS approach is not well understood
  - Smolts (downstream) – Vemco and HTI (dam face)
  - Kelts – Post-Spawn Adults (downstream and upstream)



Acoustic Tracking Downstream

Striped bass, Atlantic & Shortnose sturgeons, Muskellunge, Atlantic salmon

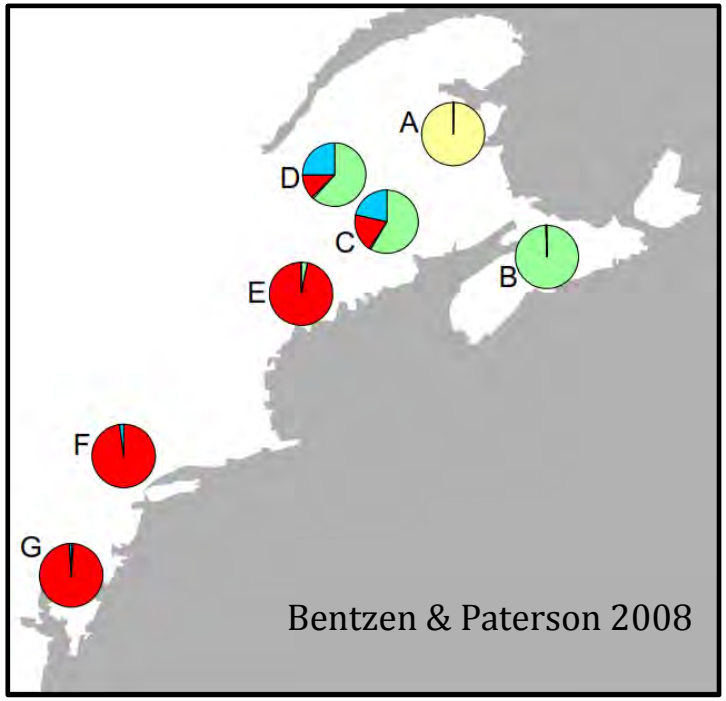
- VR2W receivers Acoustic Tagging
- >75 Vemco V16-4x acoustic tags

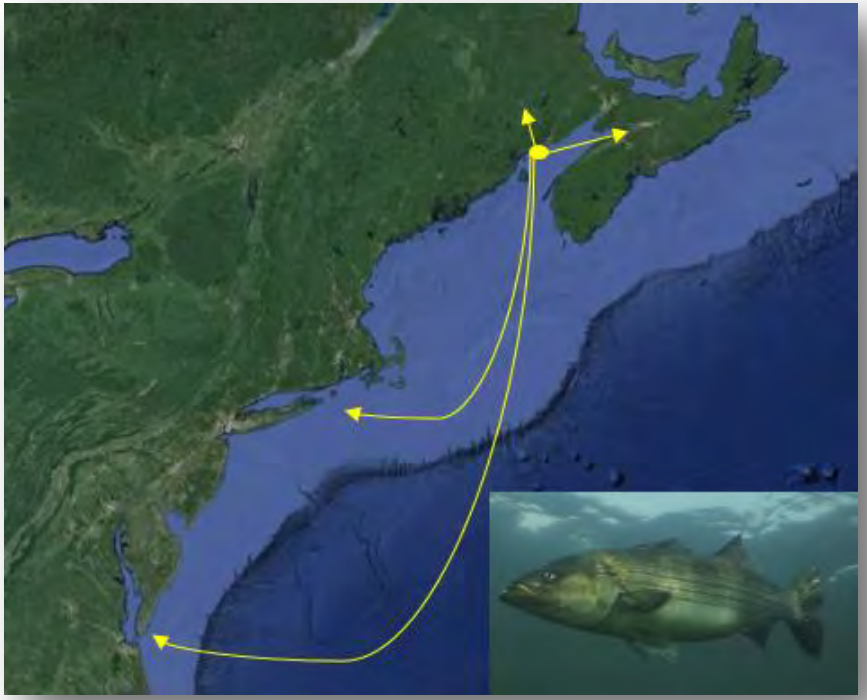


Striped Bass (*Morone saxatilis*)

Reproduction / Connectivity Issues

- No reproduction since 1970
- Do we have a native population?
- What are the population affiliations?





2.5 Near dam, spatio-temporal distribution of American Eel elvers

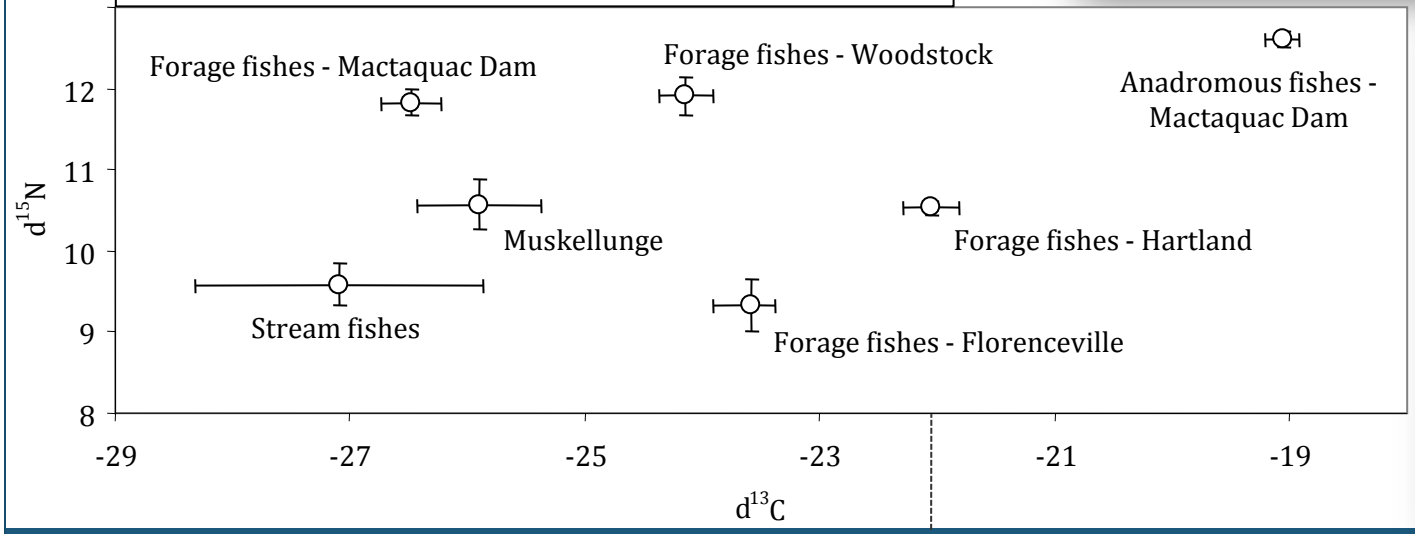
- Eel elvers are no longer reported arriving at MGS fish trap
- Use traps to study the spatio-temporal approach of elvers
- Identify migration bottleneck(s) using spatio-temporal information and the results of the hydrodynamic model

2.6 The ecology of muskellunge:

An introduced predator in the vicinity of a large dam

- 18 muskies tagged
- 3 CART tags
- 10 Vemco V-16
- 5 Lotek MCFT2 tags

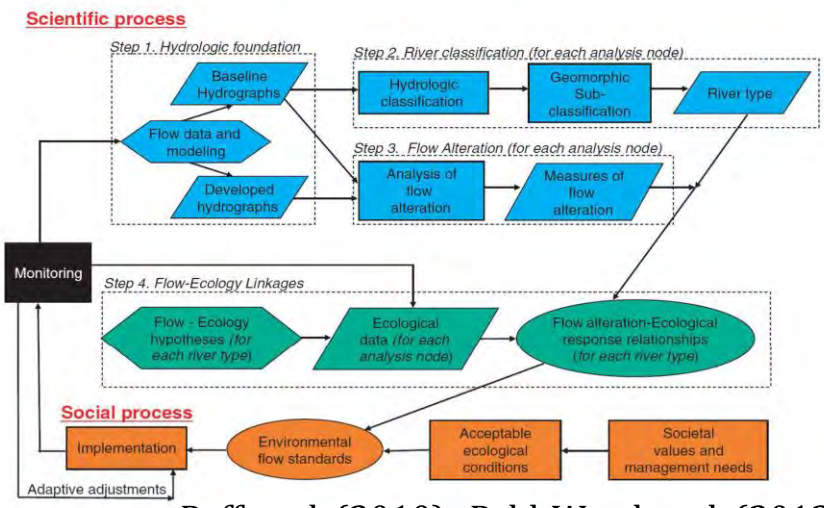
Isotope plot of fishes in the Saint John River



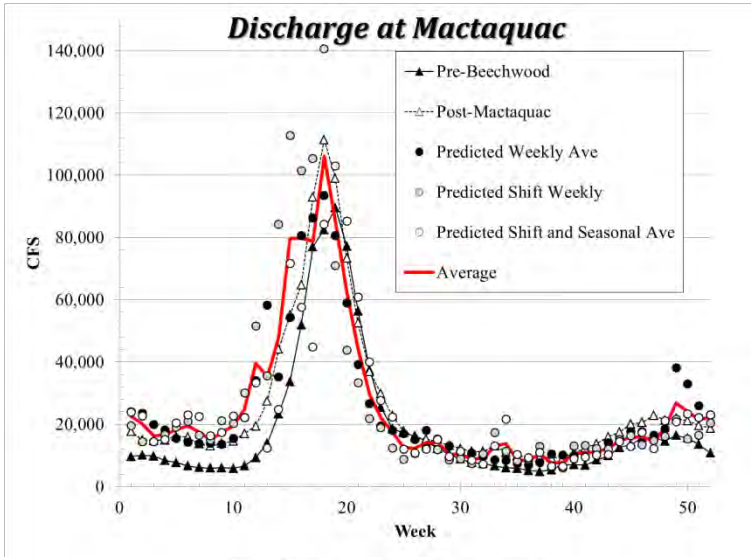
3.0 Environmental flows

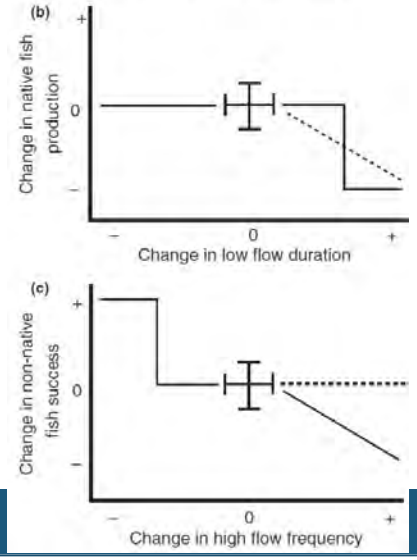
3.2 Climate and future hydrological regimes

- Quantify trends for hydrological and thermal regimes (models and climate downscaling)
- ELHOA approach underway

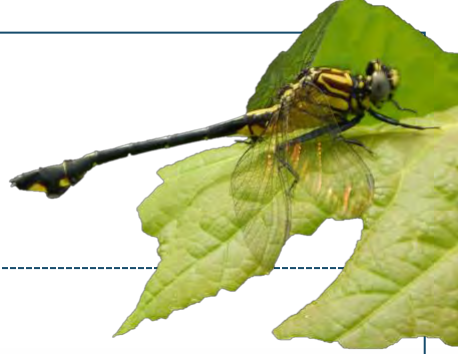


Poff et al. (2010)., Pahl-Wostl et al. (2013)





NSERC 3.3 - *Environmental and future flows with habitat implications for riparian insect species*



- Two dragonflies
  - ✓ *Gomphus ventricosus* (Skillet Clubtail) - <u>endangered</u>
  - ✓ *Ophiogomphus howei* (Pygmy Snaketail) - <u>special concern</u>
- Beetle
  - ✓ *Cicindela marginipennis* (Cobblestone Tiger Beetle) – <u>endangered</u>
- 67 sites in GLM
  - Exuvia and paired environmental variables
  - Tiger beetles - islands

Photos: Zoe O'Malley

Project summary

- Mactaquac will be the largest hydroelectric generating station ever removed or rebuilt worldwide
  - Project expected to create science, teaching and education products for the rapidly emerging science of dam renewal
- Creation of a template of approaches and methods
  - Will facilitate incorporation of aquatic ecosystem science into informed decision making and management for future hydropower projects
- Translating science into training and actions
  - Trained HQP (50+) in river science, civil/geological/geodesy and geomatics engineering will develop integrated, cross-discipline technical skills